REMARKS

Applicants have amended the claims by canceling withdrawn claim 3 from the application without prejudice or disclaimer and reserve all rights to filing a divisional application to the subject matter considered by the Examiner to represent a patentably distinct invention.

Applicants believe that the present amendment places the application in condition for allowance, but if this is not the case, Applicants request that the Examiner contact the undersigned attorney so that an interview can be arranged to determine what further amendments may be necessary to place the application in condition for allowance or in the best condition for proceeding with an appeal.

Claim Rejections - 35 USC § 103 (a)

The Examiner in charge rejected claims 1 and 2 of the present application under 35 U.S.C. 103(a) as being unpatentable over Shneerov et al. (US Pat. 4,843,212) and Cary. This rejection has been carefully considered but is most respectfully traversed.

Grounds for claim rejections presented by the examiner in charge are as follows: Shneerov et al. discloses a welding wire which is plated with copper. (However, the Examiner does not point out where in the reference is there any teaching of plating the copper onto the wire as required by the present invention.) Welding wire is made from welding rods which are cold drawn to a diameter of 0. 8 mm. (This is taught at column 5, line 10 of the reference. See the paragraph bridging columns 4 and 5 which states that the source components (which include copper) are loaded in the required amount into a steel-melting plant, melted , held as long as necessary and is charged into the steel-pouring ladle and mould. The metal is cast into ingots which are then rolled into wire rod(s). There is no teaching of coating the wire with copper as required by the presently claim invention. This is a claim limitation which cannot be ignored.) The ultimate tensile strength is 830 to 1320 MPa. Exact yield strengths are not taught. Cary discloses the mechanical properties which range from 450 to 830 MPa for tensile

strengths and 390 to 740 MPa for yield strengths. The resulting ratios range from 45 to 88 %. It would have been obvious to one of ordinary skill in the art to use the mechanical properties of Cary in the Shneerov et al. wire because these are drawn to the same welding wire products.

The prior art discloses a product substantially similar to a claimed product, differing only in the manner by which it is produced. (This statement is specifically traversed.) It has been held that one of ordinary skill in the art at the time of the invention would have considered the claimed compositions to have been obvious because of the similarity in the properties, and overlapping ranges. The burden falls to the applicant to show that any process steps associated with the claimed product result in a materially different product from those of the prior art, because there is nothing in the record before the examiner to reasonably conclude that applicant's product differs in kind from those obtained by the references.

<u>Additional Response to Claim Rejections - 35 USC § 103(a)</u>

See the requirements for establishing a prima facie case of obviousness set forth in the previous amendment and herein incorporated by reference. The present invention relates to a welding solid wire, and more particularly to a welding solid wire with high feeding performance and arc stability on welding.

US Pat. 4,843,212 to Shneerov et al. (hereinafter, referred to as "cited reference 1 ") relates to ferrous metallurgy, and more particularly to compositions of welding wire. The paper written by Cary (hereinafter, referred to as "cited reference 2") generally discloses mechanical properties of welding wires.

Comparison between the present invention and cited reference 1 in terms of object, construction, and effect will now be made in detail, and subsequently the reason why the present invention is not obvious from cited reference 2 will be fully described.

1. Detailed comparison between the present invention and cited reference 1

(1) Object

It is the object of the present invention to provide a welding solid wire with high feeding performance and arc stability on welding.

It is the object of cited reference 1 to provide a composition of a welding wire widely useful in making large metal structures and elements from carbon and low-alloy steels.

As shown in Fig. 2 of the present application, the wire is subjected to large resistance at contact points where the wire and the inner wall of a cable are contacted with each other in a bent portion of the cable in the course of feeding the wire. The object of the present invention is to minimize the aforesaid resistance of the wire by closely examining the elastic limit ratio of the wire. When the wire passes through the bent portion X or Y of the cable, the wire is subjected to large resistance, which is different depending upon whether the wire is soft or hard. The resistance of the wire is generated even when the wire is slightly bent. Consequently, the object of the present invention is to provide a wire with high feeding performance while the resistance of the wire is decreased between the bent portion and the straight welding tip portion.

On the other hand, cited reference 1 provides a composition of a welding wire having sufficiently high mechanical properties at a minimum splashing of metal in the course of welding. Cited reference 1 specifies components of the composition and contents of the components, with which an excellent welding wire is produced.

As can be seen from the above-mentioned comparison between the present invention and cited reference 1 in terms of object, it seems that the present invention is very similar to cited reference 1 in that they provide welding wires. However, the present invention, which provides a welding wire with high feeding performance by closely examining new characteristics of the wire, is definitely different from cited reference 1, which provides a composition of the welding wire comprising various components each comprising a specified percentage of the composition.

(2) Construction

The welding wire of the present invention is an arc welding solid wire whose surface comprises a copper plated film, characterized in that the elastic limit ratio, which is defined by the following equation, of the finally produced wire is controlled in the range between 50 and 88 %.

Elastic limit ratio = Elastic limit / Tensile strength

The aforesaid elastic limit ratio is controlled by installing three to eight elastic limit ratio control vertical rollers and three to eight elastic limit ratio control transverse rollers, each of which has a ratio D/d equal to 40 to 60 (where D is a roller diameter, and d is a wire diameter) following coil control vertical and transverse rollers after final drawing.

On the other hand, the welding wire of cited reference 1 is a welding wire whose composition comprises 0.03 to 0.25 mass % of carbon, 0.8 to 2.2 mass % of manganese, 0.7 to 2.2 mass % of silicon, 0.005 to 0.2 mass % of aluminum, 0.01 to 0.25 mass % of chromium, 0.01 to 0.25 mass % of copper, 0.01 to 0.25 mass % of nickel, 0.001 to 0.02 mass % of calcium, 0.01 to 0.1 mass % of rare-earth metals, and the balance of iron.

The following is described at the upper part of the fifth column, which is part of "DETAILED DESCRIPTION OF THE INVENTION" section, of cited reference 1.

"Making wire rods of 5.5 - 6.5 mm diameter from the proposed composition is technologically simple. The mechanical properties of the wire rod are as follows: ultimate strength not over 740 MPa, reduction of area not under 48 %. The welding wire produced from wire rods can be made by cold drawing of the wire rod to a diameter of 0. 8 mm and over with or without subsequent copper plating. The ultimate strength of the produced welding wire is 830 to 1320 MPa."

The Examiner in charge has the opinion that cited reference 1 discloses the ultimate tensile strength of 830 to 1320 MPa although it does not teach the exact yield strengths.

However, the aforesaid ultimate tensile strength is merely the ultimate tensile strength of the wire having a diameter of 0.8 mm.

The present invention limits the ratio of the elastic limit to the tensile strength to specific ranges to improve the feeding performance of the welding wire. The elastic limit is a value corresponding to the permanent elongation ratio of 0.05 % on the stress-elongation ratio diagram of Fig. 5 of the present application. The present invention does not specify the diameter of the wire and the ranges of the tensile strength as in cited reference 1.

Furthermore, the present invention provides the elastic limit ratio control rollers to control the elastic limit ratio. According to the present invention, the welding wire passes through three to eight elastic limit ratio control vertical rollers and three to eight elastic limit ratio control transverse rollers, each of which has a ratio D/d equal to 40 to 60. The elastic limit ratio control rollers are composed of five U-shaped hang-on rollers between guide rollers, as shown in Fig. 7 of the present application. The elastic limit ratio of 50 to 88 % cannot be obtained only by drawing. It should be noted that the elastic limit ratio can be controlled by using the elastic limit ratio control rollers of the present invention.

Cited reference 1 does not teach the elastic limit at all. Cited reference 1 merely discloses the mechanical properties, such as the tensile strength and the yield strength, of the welding wire having the composition clearly described in the specification of cited reference 1. The tensile strength and the yield strength are the mechanical properties of common wires, which are not novel. Furthermore, the cited reference 1 discloses no apparatus for controlling the mechanical properties of the welding wire. Consequently, cited reference 1 merely discloses the composition of the welding wire.

As can be seen from the above-mentioned comparison between the present invention and cited reference 1 in terms of construction, the present invention, which provides an apparatus for controlling the mechanical properties of the welding wire to obtain the welding wire with improved mechanical properties, is definitely different from cited reference 1, which merely claims the composition of a welding wire. Moreover, there is no recognition of the problem which is solved by the present, let alone its solution which is the subject of the presently claimed invention. The necessary motivation to modify the references to arrived at the presently claimed invention is not

present in the prior art. Obvious to try is not the standard of obviousness under 35 USC 103(a).

(3) Effect

According to the present invention, feeding performance and arc stability of the welding wire is highly improved. Consequently, good welding beads which have neither slag inclusion nor meandering beads, and also less spatter, can be easily achieved.

As indicated in Table 1 of the specification of the present application, if the elastic limit ratio of the wire itself is controlled in the range between 50 and 88 %, it is clear that neither slag inclusion nor meandering bead occurs, resulting in decrease of current on welding and the number of spatters each having a diameter of over 1 mm, so that a good welding bead can be achieved. Consequently, the welding wire having the elastic limit ratio in the range between 50 and 88 % has a remarkably distinct effect as compared to other wires each having the elastic limit ratio outside of the range between 50 and 88 %. The reduction rate of a coil diameter y is decreased up to nine times, and the arc height x is decreased up to five times, especially when the ratio D/d is 40 to 60 and the number of the U-shaped hang-on rollers is 3 to 8. In case where the wire has the elastic limit ratio of the range between 50 and 88 %, the contact of the wire with the inner wall of the cable is considerably decreased, whereby the feeding performance of the wire is improved.

On the other hand, cited reference 1 merely teaches the ultimate strength of the welding wire having the composition specified in the specification of cited reference 1. Cited reference 1 dose not teach the effect obtained by providing the ultimate strength. Moreover, cited reference 1 does not specify ranges of the ultimate strength. Cited reference 1 merely discloses that the ultimate strength of the wire having a diameter of 0.8 mm is 830 to 1320 MPa.

As can be seen from the above-mentioned comparison between the present invention and cited reference 1, the present invention is also quite different from cited reference 1 in terms of effect. According to the present invention, the elastic limit, which is a novel mechanical property of the present invention, is presented, and the rollers for

controlling the elastic limit ratio are provided. Consequently, the welding wire of the present invention has excellent feeding performance and arc stability as well as other superior characteristics of the wire.

(4) Conclusion

As mentioned above, the present invention is quite different from cited reference 1 in terms of object and construction. Furthermore, the present invention has the effect different from cited reference 1 since the construction of the present invention is different from that of cited reference 1. The present invention specifies the elastic limit ratio, and provides an apparatus for controlling the elastic limit ratio within the specific ranges. Consequently, the present invention provides a welding wire with improved feeding performance, by which the wire can be produced with high efficiency.

2. Detailed comparison between the present invention and cited reference 2

Cited reference 2 generally discloses various properties of a welded metal sample welded with a shielded metal arc welding rod given in the specification of American Welding Society (AWS) . The examiner in charge has the opinion that cited reference 2 discloses the mechanical properties which range from 450 to 830 MPa for tensile strengths and 390 to 740 MPa for yield strengths, and the resulting ratios range from 45 to 88 %.

The properties considered in a tensile test of the metal will be hereinafter described in detail.

The properties related to the mechanical deformation of the metal material are called the mechanical properties of the material. The test for measuring the mechanical properties is generally classified into a static test and a dynamic test on the basis of status and condition of a load. The most widely utilized static test is a tensile test, which is provided for measuring the strengths of metals or alloys. The tensile test is carried out at a normal temperature to measure the properties of the material, such as yield strength, tensile strength, drawing ratio, reduction rate of section, etc.

A basic diagram which can be obtained from the tensile test is a load-elongation diagram showing the relation between the applied load and the resultant elongation. The strength of a load acting on unit cross-sectional area when the load is applied is called stress, and the ratio of the amount of change of the original gauge length on the basis of the applied load to the original gauge length is called strain. The load is divided by the original cross-sectional area, and the elongation is divided by the original gauge length on the load-elongation diagram, to obtain a stress-strain diagram. Fig. 1 shows an exemplary stress-strain diagram of soft steel, which is given below.

Fig. 1

The points on the stress-strain diagram represent the properties as indicated in Table 1, which is given below, respectively.

[-Table 1]

1	Proportional limit	The maximum stress at which the curve in the stress-strain diagram is a straight line, i.e., the strain is linearly proportional to the stress.
2	Elastic limit	The maximum stress at which the material will return to its original state without causing permanent deformation after the load applied approximately at the proportional limit is
		removed. It is difficult to determine the exact elastic limit. For this reason, the stress at which permanent deformation of the material is substantially caused to some extent is defined as the elastic limit. Generally, the value of 0.01 to 0.03 % is adopted as the ratio of the permanent deformation.
3	Yield point	After it exceeds the elastic limit, the stress increases logarithmically. However, there exists a point at which the deformation of the material is abruptly increased even though the load is not increased after the stress exceeds the elastic limit. The point is called an upper yield point. At this time, a plastic flow is generated due to a slip in the metal material, by which large inner transposition is caused to generate a lower yield point. The

		permanent deformation is further increased as the material exceeds the lower yield point. Generally, the yield point means the lower yield point.
4	0.2 % offset yield strength	Copper or aluminum does not have a sharply defined yield point. Therefore, the point at which the material has 0. 2 % of the ratio of the permanent deformation is considered as the yield point, which is called 0.2 % offset yield strength or proof stress.
5	Ultimate Strength	After it exceeds the yield point, the material is hardened. Consequently, the deformation is increased only when the load is increased. After a prescribed load is applied, the ratio of maximum load applied to the material sample to original cross-sectional area is measured, which is the ultimate strength.

The Examiner in charge has the opinion that the ratio of the yield strength to the tensile strength disclosed in cited reference 2 falls into the scope of the present invention, which means that the examiner in charge merely considers the yield strength of cited reference 2 as the elastic limit of the present invention. However, the elastic limit is quite different from the yield strength.

Cited reference 2 teaches 0.2 % offset yield strength. The applicant submits documentary evidence I which clearly shows that the yield strength disclosed in cited reference 2 is the 0.2 % offset yield strength. Documentary evidence I shows the specification of a corresponding arc welding rod presented in American Society of Mechanical Engineers (ASME), which is equivalent to the aforesaid American Welding Society (AWS).

Furthermore, the applicant submits documentary evidence II which clearly shows that the yield strength or proof stress and the elastic limit are quite different concepts. As can be seen from Fig. 10 at page 189 of documentary evidence II, the elastic limit varies widely as the yield point or the proof strength is changed. The elastic limit is decreased even though the proof stress is increased. The proof stress is controllable, while the elastic limit is not controllable.

As mentioned above and can be seen from the documentary evidences submitted herewith, the yield strength of cited reference 2 is quite different from the elastic limit of the present invention. The elastic limit theoretically has the ratio of the permanent deformation at 0.01 to 0.03 % offset, especially at 0.05 % offset according to the present invention. Nevertheless, the Examiner in charge considers the elastic limit as the yield strength, and thus simply divides the yield strength by the tensile strength to compare the ratio of the yield strength to the tensile strength with the elastic limit ratio of the present invention, which is obviously a mistake of the examiner in charge. The ratio of the yield strength to the tensile strength does not correlate to the improvement of feeding performance of the wire.

The yield strength and the tensile strength are obtained at the same time when the tensile test of the relevant material is carried out. Consequently, it is obviously inappropriate that the ratio of the minimum yield strength, which is one of the yield strengths measured at several points of the welding rod of cited reference 2, to the maximum tensile strength, which is also one of the tensile strengths measured at several points of the welding rod of cited reference 2, is set to the lower limit (45 %), and the ratio of the maximum yield strength to the minimum tensile strength is set to the upper limit (88 %).

The present invention specifies the ratio of the elastic limit to the tensile strength, which is quite different from the ratio of the yield strength to the tensile strength. The ratio of the elastic limit to the tensile strength cannot be obtained only by drawing the wire. The ratio of the elastic limit to the tensile strength can be obtained within the desired ranges only by providing elastic control rollers.

The ratio of the elastic limit to the tensile strength, i.e., the elastic limit ratio is not taught by cited reference 2. Therefore, it is obviously impossible even for those skilled in the technical art to which the invention pertains to suggest a welding wire with improved feeding performance by deriving the elastic limit ratio from cited reference 2 and limiting the elastic limit ratio to specific ranges.

3. Conclusion

The present invention specifies the elastic limit ratio of the wire to provide the wire with improved feeding performance. Also, the present invention provides elastic control rollers to limit the elastic limit ratio to specific ranges. Consequently, the present invention is quite different from cited references 1 and 2 in terms of object and construction. Furthermore, the present invention has the effect different from cited references 1 and 2 since the construction of the present invention is different from those of cited references 1 and 2. In conclusion, it is obviously impossible for those skilled in the technical art to which the invention pertains to derive the aforesaid technical idea of the present invention from cited references 1 and 2, absent Applicants' teaching which would result in impermissible hindsight.

Applicants wish to direct the Examiner's attention to the decision of the CAFC In re Demibiczak, 50 USPQ2d 1614, which is quoted extensively in the following paragraphs for its statement of the criteria for establishing a prima facie case of obviousness. Applicants believe that the present rejection does not establish that the claimed invention is prima facie obvious. The following is from the decision, pages 1616 -1618.

> Our analysis begins in the text of section 103 quoted above, with the phrase "at the time the invention was made." For it is this phrase that guards against entry into the "tempting but forbidden zone of hindsight," see Loctite Corp. v. Ultraseal Ltd., 781 F.2d861, 873, 228 USPQ 90, 98 (Fed. Cir. 1985), overruled on other grounds by Nobelpharma AB v. Implant Innovations, Inc., 141F.3d 1059, 46 USPQ2d 1097 (Fed. Cir. 1998),
>
> Page 1617
>
> when analyzing the patentability of claims pursuant to that section. Measuring a claimed invention against the standard established by section 103 requires the oft-difficult but critical step of casting the mind back to the time of invention, to consider the thinking of one of ordinary skill in the art, guided only by the prior art references and the then-accepted wisdom in the field. See, e.g., W.L. Gore & Assoc., Inc. v. Garlock, Inc., 721 F.2d1540, 1553, 220 USPQ 303, 313 (Fed. Cir. 1983). Close adherence to this methodology is especially important in the

case of less technologically complex inventions, where the very ease with which the invention can be understood may prompt one "to fall victim to the insidious effect of a hindsight syndrome wherein that which only the inventor taught is used against its teacher." Id.

Our case law makes clear that the best defense against the subtle but powerful attraction of a hindsight-based obviousness analysis is rigorous application of the requirement for a showing of the teaching or motivation to combine prior art references. See, e.g., C.R. Bard, Inc. v. M3 Sys., Inc., 157 F.3d 1340, 1352, 48 USPQ2d1225, 1232 (Fed. Cir. 1998) (describing "teaching or suggestion or motivation [to combine]" as an "essential evidentiary component of an obviousness holding"); In re Rouffet, 149 F.3d 1350, 1359, 47USPQ2d 1453, 1459 (Fed. Cir. 1998) ("the Board must identify specifically . . . the reasons one of ordinary skill in the art would have been motivated to select the references and combine them"); In re Fritch, 972 F.2d 1260, 1265, 23 USPQ2d 1780, 1783 (Fed. Cir.1992) (examiner can satisfy burden of obviousness in light of combination "only by showing some objective teaching [leading to the combination]"); In re Fine, 837 F.2d 1071, 1075, 5 USPQ2d 1596,1600 (Fed. Cir. 1988) (evidence of teaching or suggestion "essential" to avoid hindsight); Ashland Oil, Inc. v. Delta Resins & Refractories, Inc., 776 F.2d 281, 297, 227 USPQ 657, 667 (Fed.Cir. 1985) (district court's conclusion of obviousness was error when it "did not elucidate any factual teachings, suggestions or incentives from this prior art that showed the propriety of combination"). See also Graham, 383 U.S. at 18, 148 USPQ at 467 ("strict observance" of factual predicates to obviousness conclusion required). Combining prior art references without evidence of such a suggestion, teaching, or motivation simply takes the inventor's disclosure as a blueprint for piecing together the prior art to defeat patentability--the essence of hindsight. See, e.g., Interconnect Planning Corp. v. Feil, 774 F.2d 1132, 1138, 227USPQ 543, 547 (Fed. Cir. 1985) ("The invention must be viewed not with the blueprint drawn by the inventor, but in the state of the art that existed at the time."). In this case, the Board fell into the hindsight trap.

We have noted that evidence of a suggestion, teaching, or motivation to combine may flow from the prior art references themselves, the knowledge of one of ordinary skill in the art, or, in some cases, from the nature of the problem to be solved, see Pro-Mold &Tool Co. v. Great Lakes Plastics, Inc., 75 F.3d 1568, 1573, 37USPQ2d 1626, 1630 (Fed. Cir. 1996), Para-Ordinance Mfg. v. SGS Imports Intern., Inc., 73 F.3d 1085, 1088, 37 USPQ2d 1237, 1240(Fed. Cir. 1995), although "the suggestion more often comes from the teachings of the pertinent references," Rouffet, 149 F.3d at 1355, 47 USPQ2d at 1456. The range of sources available, however, does not diminish the requirement for actual evidence. That is, the showing must be clear and particular. See,

> e.g., C.R. Bard, 157 F.3d at 1352, 48 USPQ2d at 1232. Broad conclusory statements regarding the teaching of multiple references, standing alone, are not "evidence." E.g. ,...

The Examiner's attention is also directed to MPEP section 2143.03 which states that all claim limitations must be taught or suggested by the prior art. In re Royka, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). "All words in a claim must be considered in judging the patentability of that claim against the prior art." In re Wilson, 424 F.2d 1382, 1385, 165 USPQ 494, 496 (CCPA 1970). Accordingly, it is most respectfully requested that this rejection be withdrawn.

In view of the above comments, favorable reconsideration and allowance of all of the claims now present in the application are most respectfully requested.

Respectfully submitted,

BACON & THOMAS, PLLC

By: Richard E. Fichter
Richard E. Fichter
Registration No. 26,382

625 Slaters Lane, 4th Fl.
Alexandria, Virginia 22314
Phone: (703) 683-0500
Facsimile: (703) 683-1080

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June 25, 2003

ASME BOILER AND PRESSURE VESSEL CODE
AN INTERNATIONAL CODE

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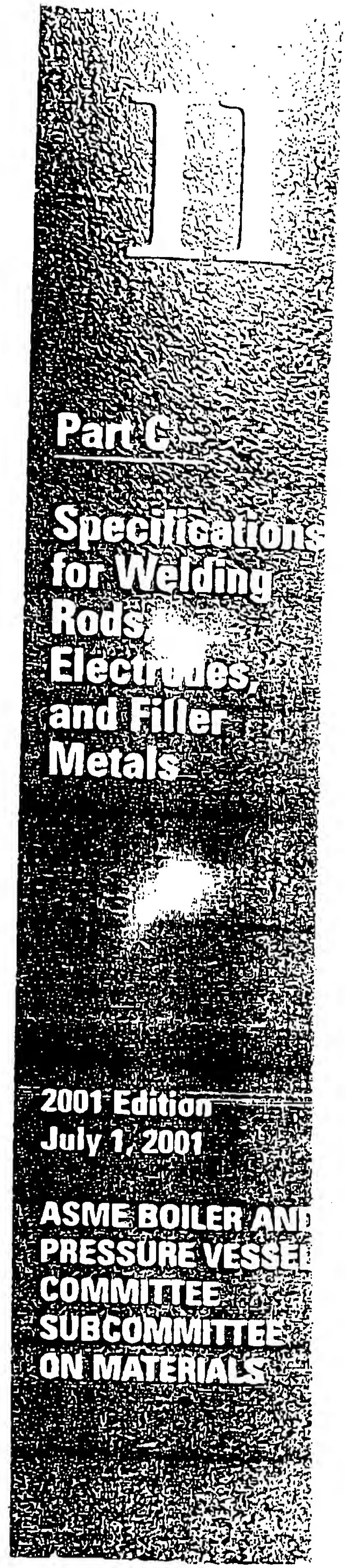
MATERIALS



THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
NEW YORK, NEW YORK

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SPECIFICATION FOR CARBON STEEL ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW)

SFA-5.1

(Identical with AWS Specification A5.1-91)

1. Scope

This specification prescribes requirements for the classification of carbon steel electrodes for shielded metal arc welding.

PART A — GENERAL REQUIREMENTS

2. Classification

2.1 The welding electrodes covered by this specification are classified according to the following:

(*1*) Type of current (see Table 1)
(*2*) Type of covering (see Table 1)
(*3*) Welding position (see Table 1)
(*4*) Mechanical properties of the weld metal in the as-welded or aged condition (see Tables 2 and 3)

2.2 Materials classified under one classification shall not be classified under any other classification of this specification, except that E7018M may also be classified as E7018 provided the electrode meets all of the requirements of both classifications.

3. Acceptance

Acceptance[1] of the welding electrodes shall be in accordance with the provisions of the ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*[2]

4. Certification

By affixing the AWS specification and classification designations to the packagings, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.[3]

5. Units of Measure and Rounding-Off Procedure

5.1 U.S. Customary Units are the standard units of measure in this specification. The SI Units are given as equivalent values to the U.S. Customary Units. The standard sizes and dimensions in the two systems are not identical, and for this reason, conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in the other. Suitable conversions, encompassing standard sizes of both, can be made, however, if appropriate tolerances are applied in each case.

5.2 For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded to the "nearest unit" of the last right-hand place of figures used in expressing the limiting value in accordance with the round-off method of ASTM Practice E29 for *Using Significant Digits in Test Data to Determine Conformance with Specifications.*[4]

[1] See A3 (in the Appendix) for further information concerning acceptance, testing of the material shipped, and ANSI/AWS A5.01 *Filler Metal Procurement Guidelines.*

[2] AWS standards can be obtained from the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

[3] See A4 (in the Appendix) for further information concerning certification and the testing called for to meet this requirement.

[4] ASTM standards can be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

TABLE 1
ELECTRODE CLASSIFICATION

AWS Classification	Type of Covering	Welding Position[a]	Type of Current[b]
E6010	High cellulose sodium	F, V, OH, H	dcep
E6011	High cellulose potassium	F, V, OH, H	ac or dcep
E6012	High titania sodium	F, V, OH, H	ac or dcen
E6013	High titania potassium	F, V, OH, H	ac, dcep or dcen
E6019	Iron oxide titania potassium	F, V, OH, H	ac, dcep or dcen
E6020	High iron oxide	H-fillets	ac or dcen
		F	ac, dcep or dcen
E6022[c]	High iron oxide	F, H	ac or dcen
E6027	High iron oxide, iron powder	H-fillets	ac or dcen
		F	ac, dcep or dcen
E7014	Iron powder, titania	F, V, OH, H	ac, dcep or dcen
E7015[d]	Low hydrogen sodium	F, V, OH, H	dcep
E7016[d]	Low hydrogen potassium	F, V, OH, H	ac or dcep
E7018[d]	Low hydrogen potassium, iron powder	F, V, OH, H	ac or dcep
E7018M	Low hydrogen iron powder	F, V, OH, H	dcep
E7024[d]	Iron powder, titania	H-fillets, F	ac, dcep or dcen
E7027	High iron oxide, iron powder	H-fillets	ac or dcen
		F	ac, dcep or dcen
E7028[d]	Low hydrogen potassium, iron powder	H-fillets, F	ac or dcep
E7048[d]	Low hydrogen potassium, iron powder	F, V, OH, H, V-down	ac or dcep

Notes:

a. The abbreviations indicate the welding positions as follows:

F = Flat
H = Horizontal
H-fillets = Horizontal fillets
V-down = Vertical with downward progression

V = Vertical
OH = Overhead
} For electrodes $^3/_{16}$ in. (4.8 mm) and under, except $^5/_{32}$ in. (4.0 mm) and under for classifications E7014, E7015, E7016, E7018, and E7018M.

b. The term "dcep" refers to direct current electrode positive (dc, reverse polarity). The term "dcen" refers to direct current electrode negative (dc, straight polarity).

c. Electrodes of the E6022 classification are intended for single-pass welds only.

d. Electrodes with supplemental elongation, notch toughness, absorbed moisture, and diffusible hydrogen requirements may be further identified as shown in Tables 2, 3, 10, and 11.

TABLE 2
TENSION TEST REQUIREMENTS[a,b,c]

AWS Classification	Tensile Strength		Yield Strength at 0.2% Offset		Elongation in 2 in. (50.8 mm) Percent
	ksi	MPa	ksi	MPA	
E6010	60	414	48	331	22
E6011	60	414	48	331	22
E6012	60	414	48	331	17
E6013	60	414	48	331	17
E6019	60	414	48	331	22
E6020	60	414	48	331	22
E6022[d]	60	414	not specified		not specified
E6027	60	414	48	331	22
E7014	70	482	58	399	17
E7015	70	482	58	399	22
E7016	70	482	58	399	22
E7018	70	482	58	399	22
E7024	70	482	58	399	17[e]
E7027	70	482	58	399	22
E7028	70	482	58	399	22
E7048	70	482	58	399	22
E7018M	note g	482	53–72[f]	365–496[f]	24

Notes:

a. See Table 4 for sizes to be tested.

b. Requirements are in the as-welded condition with aging as specified in 11.3.

c. Single values are minimum.

d. A transverse tension test, as specified in 11.2 and Figure 9 and a longitudinal guided bend test, as specified in Section 12, Bend Test, and Figure 10, are required.

e. Weld metal from electrodes identified as E7024-1 shall have elongation of 22% minimum.

f. For $\frac{3}{32}$ in. (2.4 mm) electrodes, the maximum for the yield strength shall be 77 ksi (531 MPa).

g. Tensile strength of this weld metal is a nominal 70 ksi (482 MPa).

PART B — TESTS, PROCEDURES, AND REQUIREMENTS

6. Summary of Tests

The tests required for each classification are specified in Table 4. The purpose of these tests is to determine the chemical composition, mechanical properties, and soundness of the weld metal; moisture content of the low hydrogen electrode covering; and the usability of the electrode. The base metal for the weld test assemblies, the welding and testing procedures to be employed, and the results required are given in Sections 8 through 17.

The supplemental tests for absorbed moisture, in Section 16, Absorbed Moisture Test, and diffusible hydrogen, in Section 17, Diffusible Hydrogen Test, are not required for classification of the low hydrogen electrodes except for E7018M, where these are required. See Notes j and n of Table 4.

7. Retest

If the results of any tests fail to meet the requirement, that test shall be repeated twice. The results of both tests shall meet the requirement. Specimens for retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement.

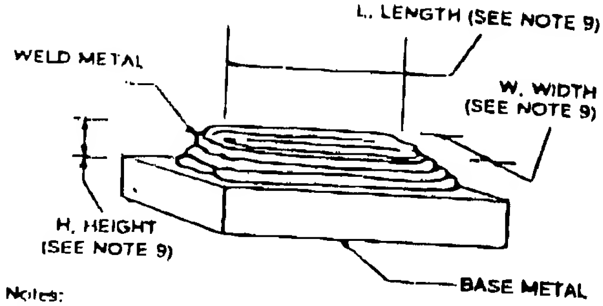
8. Weld Test Assemblies

8.1 One or more of the following five weld test assemblies are required.

(1) The weld pad in Fig. 1 for chemical analysis of the undiluted weld metal

(2) The groove weld in Fig. 2 for mechanical properties and soundness of the weld metal

(3) The fillet weld in Fig. 3 for the usability of the electrode



Notes:

1. Base metal of any convenient size, of any type specified in Table 5, shall be used as the base for the weld pad.
2. The surface of the base metal on which the filler metal is to be deposited shall be clean.
3. The pad shall be welded in the flat position with successive layers to obtain undiluted weld metal.
4. One pad shall be welded for each type of current shown in Table 4 except for those classifications identified by note L in Table 4.
5. The number and size of the beads will vary according to the size of the electrode and the width of the weave, as well as the amperage employed.
6. The preheat temperature shall not be less than 60°F (16°C) and the interpass temperature shall not exceed 300°F (150°C).
7. The slag shall be removed after each pass.
8. The test assembly may be quenched in water between passes to control interpass temperature.
9. The minimum completed pad size shall be at least four layers in height (H) with length (L) and width (W) sufficient to perform analysis. The sample for analysis shall be taken at least 1/4 in. (6.4 mm) above the original base metal surface.

FIG. 1 PAD FOR CHEMICAL ANALYSIS OF UNDILUTED WELD METAL

the assemblies shall be as prescribed in Sections 9 through 14.

Electrodes other than low hydrogen electrodes shall be tested without "conditioning." Low hydrogen electrodes, if they have not been adequately protected against moisture pickup in storage, shall be held at a temperature of 500 to 800°F (260 to 427°C) for a minimum of one hour prior to testing.

8.3 Weld Pad. A weld pad, when required, shall be prepared as specified in Fig. 1. Base metal of any convenient size of the type specified in Table 5 shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean. The pad shall be welded in the flat position with multiple layers to obtain undiluted weld metal. The preheat temperature shall not be less than 60°F (16°C) and the interpass temperature shall not exceed 300°F (150°C). The slag shall be removed after each pass. The pad may be quenched in water between passes. The dimensions of the completed pad shall be as shown in Fig. 1. Testing of this assembly shall be as specified in Section 9, Chemical Analysis.

8.4 Groove Weld

8.4.1 Mechanical Properties and Soundness. A test assembly shall be prepared and welded as specified in Figs. 2 or 5 using base metal of the appropriate type specified in Table 5. Testing of this assembly shall be as specified in Section 11, Tension Test, and Section 13, Impact Test. The assembly shall be tested in the as-welded or aged condition.

8.4.2 Transverse Tension and Bend Tests. A test assembly shall be prepared and welded as specified in Fig. 4 using base metal of the appropriate type specified in Table 5. Testing of this assembly shall be as specified in 11.2 through 11.4 and Section 12, Bend Test. The assembly shall be tested in the aged condition.

8.5 Fillet Weld. A test assembly shall be prepared and welded as specified in Table 4 and Fig. 3 using base metal of the appropriate type specified in Table 5. The welding positions shall be as specified in Table 6 and Figs. 3 and 6 according to the size and classification of electrode. Testing of the assembly shall be as specified in Section 14, Fillet Weld Test.

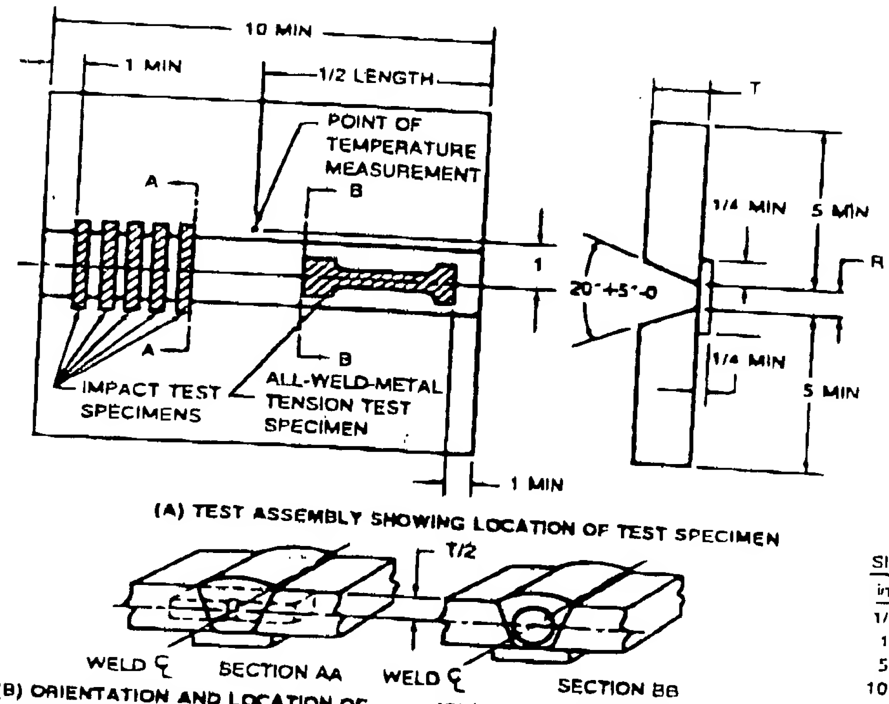
9. Chemical Analysis

9.1 The sample for analysis shall be taken from weld metal obtained with the electrode. The sample shall come from a weld pad or from a low dilution area in the fractured all-weld-metal tension specimen or the groove weld in Figs. 2 or 5. Areas where arc starts or craters exist shall be avoided.

The top surface of the pad described in 8.3 and shown in Fig. 1 shall be removed and discarded, and a sample for analysis shall be obtained from the underlying metal by any appropriate mechanical means. The sample shall be free of slag and shall be taken at least ¼ in. (6.4 mm) from the nearest surface of the base metal.

The low dilution area in the fractured tension test specimen or in the groove weld in Figs. 2 or 5 shall be prepared for analysis by any suitable mechanical means.

9.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM Standard Method E350, *Chemical Analysis of Carbon Steel,*



(A) TEST ASSEMBLY SHOWING LOCATION OF TEST SPECIMEN

(B) ORIENTATION AND LOCATION OF IMPACT TEST SPECIMEN

(C) LOCATION OF ALL-WELD-METAL TENSION TEST SPECIMEN

SI Equivalents

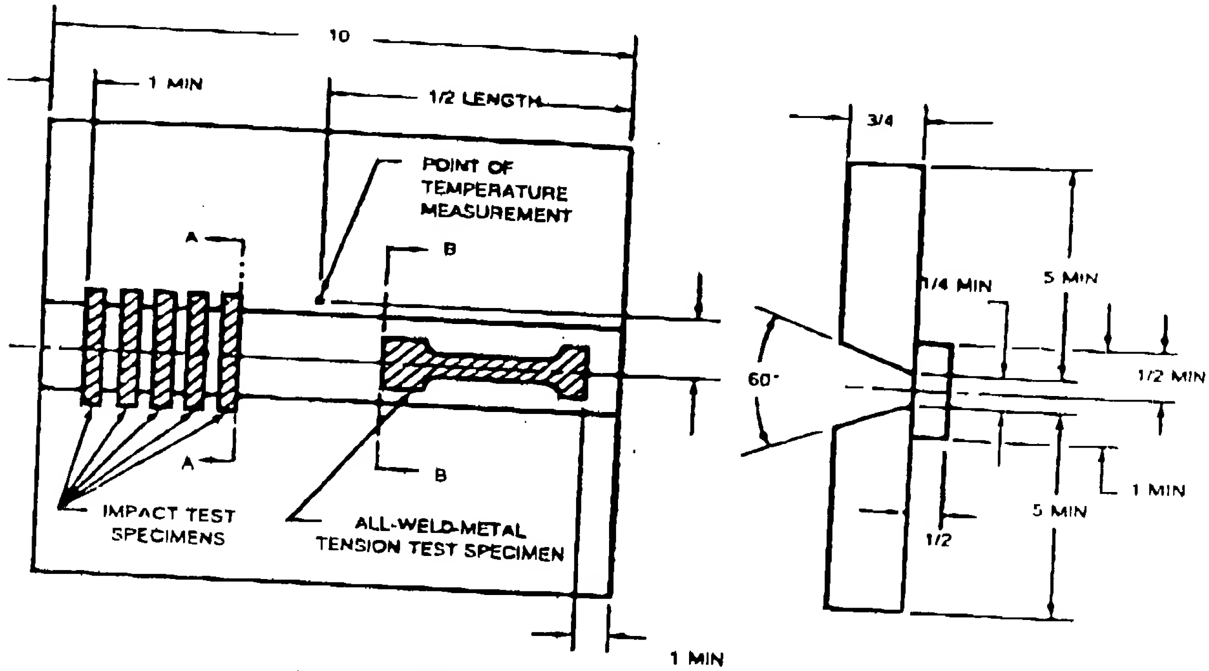
in.	mm
1/4	6.4
1	25
5	127
10	254

Electrode Size in.	Electrode Size mm	(T) Plate Thickness in.	(T) Plate Thickness mm	(R) Root Opening in.	(R) Root Opening mm	Passes Per Layer	Total Layers
3/32	2.4	1/2	13	3/8	10	2	not specified
1/8	3.2	1/2	13	1/2	13	2	5 to 7
5/32	4.0	3/4	20	5/8	16	2	7 to 9
3/16	4.8	3/4	20	3/4	20	2	6 to 8
7/32	5.6	3/4	20	7/8	23	2	6 to 8
1/4	6.4	1	25	1	25	2	9 to 11
5/16	8.0	1-1/4	32	1-1/8	28	2	10 to 12

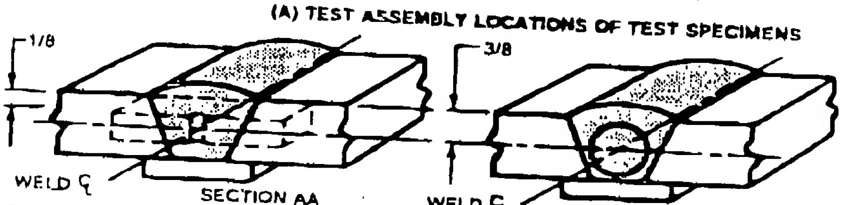
Notes:

1. All dimensions except angles are in inches.
2. For electrodes longer than 18 in. (450 mm), a 20 in. (500 mm) minimum length test assembly shall be welded.
3. Base metal shall be as specified in Table 5.
4. The surfaces to be welded shall be clean.
5. Prior to welding, the assembly may be preset to yield a welded joint sufficiently flat to facilitate removal of the test specimens. As an alternative, restraint or a combination of restraint and presetting may be used to keep the welded joint within 5 deg of plane. A welded test assembly that is more than 5 deg out of plane shall be discarded. Straightening of the test assembly is prohibited.
6. Welding shall be in the flat position, using each type of current specified in Table 4 except for classifications identified by Note L in Table 4.
7. The preheat temperature shall be 225°F (105°C) minimum. The interpass temperature shall not be less than 225°F (105°C) nor more than 350°F (175°C).
8. The joint root may be seal welded with 3/32 or 1/8 in. (2.4 or 3.2 mm) electrodes using stringer beads.
9. In addition to the stops and starts at the ends, each pass shall contain a stop and start in between the ends.
10. The completed weld shall be at least flush with the surface of the test plate.

FIG. 2 GROOVE WELD TEST ASSEMBLY FOR MECHANICAL PROPERTIES AND SOUNDNESS EXCEPT FOR E6022 AND E7018M ELECTRODES



(A) TEST ASSEMBLY LOCATIONS OF TEST SPECIMENS



(B) ORIENTATION AND LOCATION OF IMPACT TEST SPECIMEN

(C) LOCATION OF ALL-WELD-METAL TENSION TEST SPECIMEN

SI Equivalents	
in.	mm
1/8	3.2
1/4	6.4
3/8	9.5
1/2	12.7
3/4	19.1
1	25.4
5	127
10	254

Notes:

1. All dimensions except angles are in inches.
2. Base metal shall be as specified in Table 5.
3. The surfaces to be welded shall be clean.
4. Prior to welding, the assembly may be preset to yield a welded joint sufficiently flat to facilitate removal of the test specimens. As an alternative, restraint or a combination of restraint and presetting may be used to keep the welded joint within 5 deg of plane. A welded test assembly that is more than 5 deg out of plane shall be discarded. Straightening of the test assembly is prohibited.
5. The assembly shall be welded in the vertical position with progression upward for electrodes 5/32 in. (4.0 mm) and less in size, and in the flat position for electrodes 3/16 in. (4.8 mm) and greater in size, using the type of current specified in Table 4 for the electrode and welding technique recommended by the electrode manufacturer.
6. The preheat temperature and the interpass temperature shall be 200-250°F (93-121°C).
7. The welding heat input shall be 30 to 40 kJ/in. (12 to 16 kJ/cm) for the 3/32 in. (2.4 mm) size electrodes and 50 to 60 kJ/in. (20 to 24 kJ/cm) for the 1/8 in. (3.2 mm) size and larger electrodes.
8. In addition to the stops and starts at the ends, each pass shall contain a stop and start in between the ends.
9. The completed weld shall be at least flush with the surface of the test plate. Maximum weld reinforcement shall be 3/16 in. (4.8 mm). Peening of weld beads is not permitted.

FIG. 5 GROOVE WELD TEST ASSEMBLY FOR MECHANICAL PROPERTIES AND SOUNDNESS OF WELD METAL MADE WITH E7018M ELECTRODES

TABLE 5
BASE METAL FOR TEST ASSEMBLIES

AWS Classification	Base Metal		
	Type	ASTM Specification[a]	UNS Number[b]
All	Carbon steel	A131 Grade B	K02102
		A285 Grade A	K01700
		A285 Grade B	K02200
All except E7018M	Carbon steel	A285 Grade C	K02801
		A283 Grade D	—
		A36	K02600
		A29 Grade 1015	G10150
		A29 Grade 1020	G10200

NOTES:
a. Equivalent steel may be used.
b. SAE/ASTM Unified Numbering System for Metals and Alloys.

Low Alloy Steel, Silicon Electrical Steel, Ingot Iron and Wrought Iron.

9.3 The results of the analysis shall meet the requirements of Table 7 for the classification of electrode under test.

10. Radiographic Test

10.1 When required in Table 4, the groove weld described in 8.4.1 and shown in Fig. 2 or 5 shall be radiographed to evaluate the soundness of the weld metal. In preparation for radiography, the backing shall be removed, and both surfaces of the weld shall be machined or ground smooth. The finished surface of the weld may be flush with the plate or have a reasonably uniform reinforcement not exceeding $\frac{3}{32}$ in. (2.4 mm). Both surfaces of the test assembly in the area of the weld shall be smooth enough to avoid difficulty in interpreting the radiograph.

10.2 The weld shall be radiographed in accordance with ASTM Method E142, *Controlling Quality of Radiographic Testing*. The quality level of inspection shall be 2-2T.

10.3 The soundness of the weld metal meets the requirements of this specification if the radiograph shows the following:

(1) No cracks, no incomplete fusion or incomplete joint penetration

(2) No slag inclusions longer than $\frac{1}{4}$ in. (6.4 mm) or $\frac{1}{3}$ of the thickness of the weld, whichever is greater, or no groups of slag inclusions in line that have an aggregate length greater than the thickness of the weld in a length 12 times the thickness of the weld, except when the distance between the successive inclusions exceeds 6 times the length of the longest inclusions in the group.

(3) No rounded indications in excess of those permitted by the radiographic standards in Fig. 7 according to the grade specified in Table 8.

One in. (25 mm) of the weld measured from each end of the assembly shall be excluded from radiographic evaluation.

10.4 A rounded indication is an indication (on the radiograph) whose length is no more than three times its width. Rounded indications may be circular, elliptical, conical, or irregular in shape, and they may have "tails." The size of a rounded indication is the largest dimension of the indication, including any tail that may be present.

The indication may be porosity or slag. Indications whose largest dimension does not exceed $\frac{1}{64}$ in. (0.4 mm) shall be disregarded. Test assemblies with porosity indications larger than the largest rounded indications permitted in the radiographic standards do not meet the requirements of this specification.

11. Tension Test

11.1 One all-weld-metal tension test specimen shall be machined from the groove weld described in 8.4.1 as shown in Fig. 2 or 5. The dimensions of the specimen shall be as shown in Fig. 8.

11.2 For E6022 electrodes, one traverse tension test specimen shall be machined from the groove weld

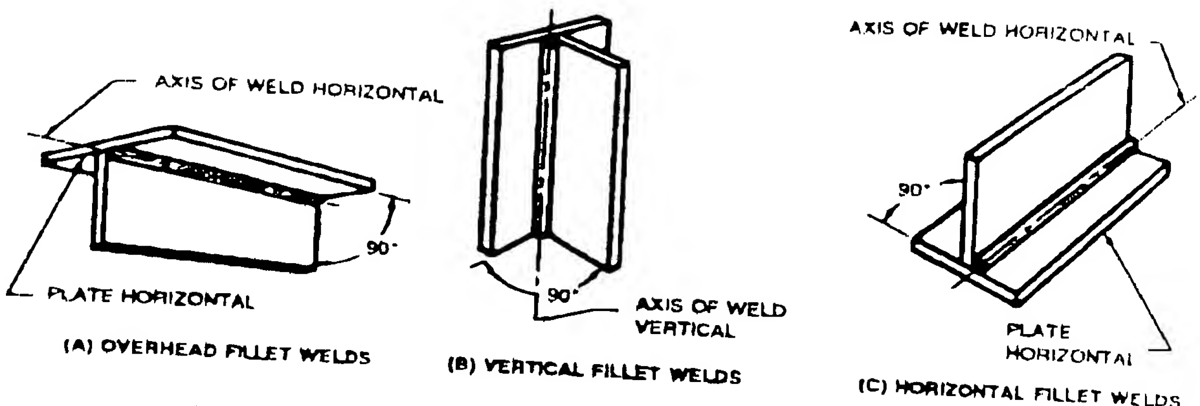


FIG. 6 WELDING POSITIONS FOR FILLET WELD TEST ASSEMBLIES

described in 8.4.2 and Fig. 4. The dimensions of the specimen shall be as shown in Fig. 9.

11.3 The tension specimens for all electrodes except the low hydrogen classifications shall be aged at 200 to 220°F (95 to 105°C) for 48 ±2 hours, and cooled in air to room temperature. All specimens shall be tested in the manner described in the tension testing section of AWS B4.0, *Standard Methods for Mechanical Testing of Welds.*

11.4 The results of the tension test shall meet the requirements specified in Table 2.

12. Bend Test (For E6022 Electrodes Only)

12.1 One longitudinal face bend specimen, as required in Table 4, shall be machined from the groove weld test assembly described in 8.4.2 and shown in Fig. 4. Dimensions of the specimen shall be as shown in Fig. 10.

12.2 The bend specimen shall be aged at 200 to 220°F (95 to 105°C) for 48 ±2 hours then air cooled to room temperature and tested as required in 12.3.

12.3 The specimen shall be tested in the manner described in the bend testing section of AWS B4.0, *Standard Methods for Mechanical Testing of Welds.* The specimen shall be bent uniformly through 180 degrees over a ¾ in. (19 mm) radius in any suitable jig. Three standard jigs are shown in Fig. 11. Positioning of the face bend specimen shall be such that the weld face of the last side welded is in tension.

12.4 Each specimen, after bending, shall conform to the ¾ in. (19 mm) radius, with an appropriate allowance for springback and the weld metal shall not contain openings in excess of ⅛ in. (3.2 mm) on the convex surface.

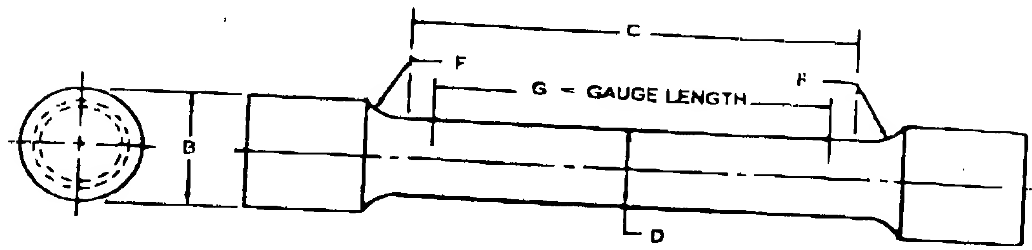
13. Impact Test

13.1 Five Charpy V-notch impact test specimens, Fig. 12, shall be machined from the test assembly shown in Fig. 2 or 5, for those classifications for which impact testing is required in Table 4.

13.2 The five specimens shall be tested in accordance with the fracture toughness testing section of AWS B4.0, *Standard Methods for Mechanical Testing of Welds.* The test temperature shall be that specified in Table 3 for the classification under test.

13.3 In evaluating the test results for all the classifications that require impact testing, except E7018M, the lowest and highest values obtained shall be disregarded. Two of the three remaining values shall equal, or exceed, the specified 20 ft-lb (27J) energy level. One of the three may be lower, but not lower than 15 ft-lb (20J). The average of the three shall not be less than the required 20 ft-lb (27J) energy level.

13.4 In evaluating the results for E7018M, all five values shall be used. Four of the five values shall equal, or exceed, the specified 50 ft-lb (67J) energy level. One of the five may be lower, but not lower than 40 ft-lb (54J). The average of the five shall not be less than the required 50 ft-lb (67J) energy level.

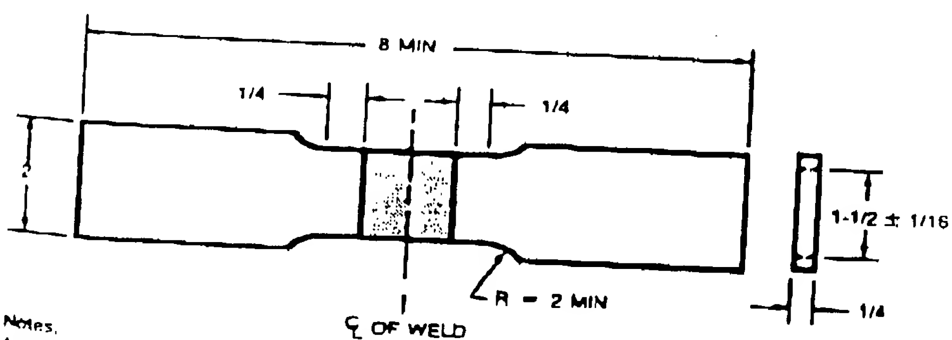


Test Plate Thickness	Dimensions of Specimen, in. D	G	C	B	F, Min
1/2	0.250 ± 0.005	1.000 ± 0.005	1-1/4	3/8	3/16
3/4 and larger	0.500 ± 0.010	2.000 ± 0.005	2-1/4	3/4	3/8

Test Plate Thickness	Dimensions of Specimen, mm D	G	C	B	F, Min
12.7	6.40 ± 0.13	25.40 ± 0.13	32	9.5	4.8
19 and larger	12.70 ± 0.25	50.80 ± 0.13	57	19	9.5

Notes:
1. Dimensions G and C shall be as shown, but ends may be of any shape to fit the testing machine holders as long as the load is axial.
2. The diameter of the specimen within the gauge length shall be slightly smaller at the center than at the ends. The difference shall not exceed one percent of the diameter.
3. When the extensometer is required to determine yield strength, dimension C may be modified. However, the percent of the elongation shall be based on dimension G.
4. The surface finish within the C dimension shall be no rougher than 63 μ in. (1.6 μ m).

FIG. 8 ALL-WELD-METAL TENSION TEST SPECIMEN DIMENSIONS



SI Equivalents in.	mm
1/4	6.4
1-1/2 ± 1/16	38.1 ± 1.6
2	51
8	203

Notes.
1. All dimensions are in inches.
2. Weld reinforcement shall be ground or machined smooth and flush with the surfaces of the specimen. Grinding or machining marks shall be parallel of the longest dimension of the specimen.

FIG. 9 TRANSVERSE TENSION TEST SPECIMEN (E6022)

Mandatory Classification Designators:*

E XX YY
E XX YY M
E XX YY -1 HZ R

- E — Designates an electrode. This designator may be deleted from the product imprint required for identification of the electrode.
- XX — Designates the tensile strength (minimum), in ksi, of the weld metal when produced in accordance with the test assembly preparation procedure of this specification. See Table 2.
- YY — Designates the welding position in which electrodes are usable, the type of covering, and the kind of welding current for which the electrodes are suitable. See Table 1.
- M — Designates an electrode (E7018M) intended to meet most military requirements (greater toughness, lower moisture content — both as-received and after exposure — and mandatory diffusible hydrogen limits for weld metal). See Table 3, 10 and 11.

Optional Supplemental Designators:

- R — Designates that the electrode meets the requirements of the absorbed moisture test (an optional supplemental test for all low hydrogen electrodes except the E7018M classification, for which the test is required). See Table 10.
- HZ — Designates that the electrode meets the requirements of the diffusible hydrogen test (an optional supplemental test of the weld metal from low hydrogen electrodes, as-received or conditioned — with an average value not exceeding "Z" mL of H_2 per 100g of deposited metal, where "Z" is 4, 8, or 16). See Table 11.
- -1 — Designates that the electrode (E7016, E7018, or E7024) meets the requirements for improved toughness — and ductility in the case of E7024 — (optional supplemental test requirements shown in Tables 2 and 3). See notes to Tables 2 and 3.

Note:
* The combination of these designators constitutes the electrode classification.

FIG. 16 ORDER OF ELECTRODE MANDATORY AND OPTIONAL SUPPLEMENTAL DESIGNATORS

print on all packages of electrodes, including individual unit packages enclosed within a larger package.

WARNING:

- **Protect yourself and others. Read and understand this information. FUMES AND GASES can be dangerous to your health. ARC RAYS can injure eyes and burn skin. ELECTRIC SHOCK can kill.**
- Before use, read and understand the manufacturer's instructions, Material Safety Data Sheets (MSDSs), and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases away from your breathing zone, and the general area.
- Wear correct eye, ear, and body protection.
- Do not touch electrical parts.
- See American National Standard Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society, 550 North LeJeune Road, P.O. Box 351040, Miami, Florida, 33135; *OSHA Safety and Health Standards*, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, D.C. 20402.

DO NOT REMOVE THIS INFORMATION

II

SPECIFICATION FOR LOW-ALLOY STEEL ELECTRODES FOR SHIELDED METAL ARC WELDING

SFA-5.5

(Identical with AWS Specification A5.5-96.)

1. Scope

This specification prescribes requirements for the classification of low-alloy steel electrodes for shielded metal arc welding of carbon and low-alloy steels. These electrodes include steel alloys in which no single alloying element exceeds 10.5 percent.

PART A — GENERAL REQUIREMENTS

2. Classification

2.1 The welding electrodes covered by this specification are classified according to the following:

(a) Type of current (Table 1)

(b) Type of covering (Table 1)

(c) Welding position (Table 1)

(d) Chemical composition of the weld metal (Table 2)

(e) Mechanical properties of the weld metal in the as-welded or postweld heat-treated condition (Tables 3 and 4)

2.2 Material classified under one classification shall not be classified under any other classification in this specification.

3. Acceptance

Acceptance[1] of the welding electrode shall be in accordance with the provisions of the ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*

4. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.[2]

5. Units of Measure and Rounding-Off Procedure

5.1 U.S. customary units are the standard units of measure in this specification. The SI units are given as equivalent values to the U.S. customary units. The standard sizes and dimensions in the two systems are not identical and for this reason conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in the other. Suitable conversions, encompassing standard sizes of both, can be made, however, if appropriate tolerances are applied in each case.

5.2 For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded "to the nearest unit" in the last right hand place of figures used in expressing the limiting value in accordance with the rounding-off rules given in ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.*

[1] See Section A1, Acceptance (in the Appendix), for further information concerning acceptance, testing of the material shipped, and ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*

[2] See Section A4, Certification (in the Annex), for further information concerning certification and the testing called for to meet this requirement.

TABLE 3
TENSION TEST REQUIREMENTS[a,b]

AWS Classification[c]	Tensile Strength		Yield Strength, at 0.2% Offset		Elongation Percent	Postweld Condition[d]
	ksi	MPa	ksi	MPa		
E7010-P1	70	480	60	415	22	AW
E7010-A1	70	480	57	390	22	PWHT
E7010-G	70	480	57	390	22	AW or PWHT
E7011-A1	70	480	57	390	22	PWHT
E7011-G	70	480	57	390	22	AW or PWHT
E7015-X	70	480	57	390	25	PWHT
E7015-B2L	75	520	57	390	19	PWHT
E7015-G	70	480	57	390	25	AW or PWHT
E7016-X	70	480	57	390	25	PWHT
E7016-B2L	75	520	57	390	19	PWHT
E7016-G	70	480	57	390	25	AW or PWHT
E7018-X	70	480	57	390	25	PWHT
E7018-B2L	75	520	57	390	19	PWHT
E7018-C3L	70	480	57	390	25	AW
E7018-W1	70	480	60	415	25	AW
E7018-G	70	480	57	390	25	AW or PWHT
E7020-A1	70	480	57	390	25	PWHT
E7020-G	70	480	57	390	25	AW or PWHT
E7027-A1	70	480	57	390	25	PWHT
E7027-G	70	480	57	390	25	AW or PWHT
E8010-P1	80	550	67	460	19	AW
E8010-G	80	550	67	460	19	AW or PWHT
E8011-G	80	550	67	460	19	AW or PWHT
E8013-G	80	550	67	460	16	AW or PWHT
E8015-X	80	550	67	460	19	PWHT
E8015-B3L	80	550	67	460	17	PWHT
E8015-G	80	550	67	460	19	AW or PWHT
E8016-X	80	550	67	460	19	PWHT
E8016-C3	80	550	68 to 80[e]	470 to 550[e]	24	AW
E8016-C4	80	550	67	460	19	AW
E8016-G	80	550	67	460	19	AW or PWHT
E8018-X	80	550	67	460	19	PWHT
E8018-B3L	80	550	67	460	17	PWHT
E8018-C3	80	550	68 to 80[e]	470 to 550[e]	24	AW
E8018-C4	80	550	67	460	19	AW
E8018-NM1	80	550	67	460	19	AW
E8018-W2	80	550	67	460	19	AW
E8018-G	80	550	67	460	19	AW or PWHT
E9010-G	90	620	77	530	17	AW or PWHT
E9011-G	90	620	77	530	17	AW or PWHT
E9013-G	90	620	77	530	14	AW or PWHT
E9015-X	90	620	77	530	17	PWHT
E9015-G	90	620	77	530	17	AW or PWHT
E9016-X	90	620	77	530	17	PWHT
E9016-G	90	620	77	530	17	AW or PWHT
E9018M	90	620	78 to 90[e]	540 to 620[e]	24	AW
E9018-X	90	620	77	530	17	PWHT
E9018-G	90	620	77	530	17	AW or PWHT

TABLE 3 (CONT'D)
TENSION TEST REQUIREMENTS[a,b]

AWS Classification[c]	Tensile Strength		Yield Strength, at 0.2% Offset		Elongation Percent	Postweld Condition[d]
	ksi	MPa	ksi	MPa		
E10010-G	100	690	87	600	16	AW or PWHT
E10011-G	100	690	87	600	16	AW or PWHT
E10013-G	100	690	87	600	13	AW or PWHT
E10015-X	100	690	87	600	16	PWHT
E10015-G	100	690	87	600	16	AW or PWHT
E10016-X	100	690	87	600	16	PWHT
E10016-G	100	690	87	600	16	AW or PWHT
E10018M	100	690	88 to 100	610 to 690[e]	20	AW
E10018-X	100	690	87	600	16	PWHT
E10018-G	100	690	87	600	16	AW or PWHT
E11010-G	110	760	97	670	15	AW or PWHT
E11011-G	110	760	97	670	15	AW or PWHT
E11013-G	110	760	97	670	13	AW or PWHT
E11015-G	110	760	97	670	15	AW or PWHT
E11016-G	110	760	97	670	15	AW or PWHT
E11018-G	110	760	97	670	15	AW or PWHT
E11018M	110	760	98 to 110	680 to 760[e]	20	AW
E12010-G	120	830	107	740	14	AW or PWHT
E12011-G	120	830	107	740	14	AW or PWHT
E12013-G	120	830	107	740	11	AW or PWHT
E12015-G	120	830	107	740	14	AW or PWHT
E12016-G	120	830	107	740	14	AW or PWHT
E12018-G	120	830	107	740	14	AW or PWHT
E12018M	120	830	108 to 120	745 to 830[e]	18	AW
E12018M1	120	830	108 to 120	745 to 830[e]	18	AW

NOTES:
a. See Table 5 for sizes to be tested.
b. Single values are minimum, except as otherwise specified.
c. The letter suffix "X" as used in this table represents the suffixes (A1, B1, B2, etc.) except for those classifications which are tested in the as-welded condition.
d. "AW" signifies as-welded with aging when it is specified in 11.2, "PWHT" signifies postweld heat treated as specified in 8.4.2 and in Table 7, except that the "G" designated classifications, marked as "AW or PWHT" in this table, may have weld metal tested with or without PWHT as agreed between the supplier and purchaser.
e. For $\frac{3}{32}$ in. (2.4 mm) electrodes, the upper value for the yield strength may be 5 ksi (35 MPa) higher than the indicated value.

hydrogen electrodes, that have not been adequately protected against moisture absorption in storage, shall be held at a temperature of 500° to 800°F (260° to 427°C) for a minimum of one hour prior to testing.

8.3 Weld Pad. A weld pad, when required, shall be prepared as specified in Fig. 1. Base metal of any convenient size of the type specified in Table 6 shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean. The pad shall be welded in the flat position with multiple layers to obtain undiluted weld metal. The preheat temperature shall not be less than 60°F (16°C) and the interpass temperature shall not exceed 300°F (150°C). Each weld pass shall be a single straight pass with the pass width not exceeding 2½ times the diameter of the core wire. The slag shall be removed after each pass. The pad may be quenched in water between passes. The dimensions of the completed pad shall be as shown in Fig. 1. Testing of this assembly shall be as specified in Section 9, Chemical Analysis.

8.4 Groove Weld

8.4.1 Mechanical Properties and Soundness. A test assembly shall be prepared and welded as specified in Fig. 2 or 4 using base metal of the appropriate type specified in Table 6, of thickness specified in Fig. 2 or 4. Testing of this assembly shall be as specified in

Mandatory Classification Designators*:

Designates an electrode. This designator may be deleted from the actual product imprint required for the identification of the electrode.

Designates the tensile strength (minimum), in ksi, of the weld metal when produced in accordance with the test assembly preparation section of this specification. See Table 3.

Designates the welding position in which electrodes are usable, the type of covering, and the kind of current for which the electrodes are suitable. See Table 1.

Designates the chemical composition of the undiluted weld metal produced by the electrode using shielded metal arc welding. See Table 2.

E (X)XX YY -X
E (X)XX YY M
E (X)XX YY M1
E (X)XX YY M-HZ
E (X)XX YY M1-HZ
E (X)XX YY -X-HZ R

Designates an electrode intended to meet most military requirements (greater toughness and elongation). See Tables 3 and 4.

Optional Supplemental Designators:

Designates that the electrode met the requirements of the absorbed moisture test (an optional supplemental test for all low hydrogen electrodes). See Table 11.

Designates that the electrode met the requirements of the diffusible hydrogen test (an optional supplemental test of the weld metal from low hydrogen electrodes, as-received or conditioned — with an average value not exceeding "Z" ml of H_2 per 100g of deposited metal, where "Z" is 4, 8, or 16). See Table 12.

*The combination of these designators constitutes the electrode classification.

FIG. 12 ORDER OF ELECTRODE MANDATORY AND OPTIONAL SUPPLEMENTAL DESIGNATORS